

author's name into confounding the present book with one on the same subject published many years ago by Capt. Thomas Brown.

OUR BOOK SHELF

The Gold-Mines of Midian and the Ruined Midianite Cities. A Fortnight's Tour in North-Western Arabia. By Richard F. Burton. (London: Kegan Paul and Co., 1878.)

CAPTAIN BURTON has managed to make a wonderfully interesting and really valuable book out of his fortnight's visit to the ancient land of Midian, on the north-east side of the Red Sea, on and to the south of the Gulf of Akabah. Long ago he had good reason to believe that in this region gold was to be found, but only in March and April of last year was he able to test his surmise, under the auspices and at the expense of the Khedive. The result of this visit is that he is satisfied that there exists a real Ophir, a regular California, extensively worked in ancient times, and whose valuable product is probably not unknown to the tribes who haunt it at the present day. Not only gold exists there, but vast deposits of iron, with copper, tin, and other metals—in fact a welcome treasure-house for the impecunious Khedive. Capt. Burton has hopes that modern Midian, now almost a desert, may yet rival the ancient land from whose people the Israelites, in the exercise of their divine vocation, carried off “the gold and the silver, the brass, the iron, the tin, the lead.” Capt. Burton made a minute inspection of some of the ancient sites, and has a good deal to say on the archaeology of the region, as well as its zoology, botany, and geology. But the book is not nearly all on the land of Midian. From the time that the author left Trieste for Alexandria and Cairo, by Suez to Midian, till his return, he saw many things on which, in his own digressive and parenthetical style, he has much to say that is worth listening to. Capt. Burton has just returned from another visit to Midian, and no doubt we shall soon have another work or an enlarged edition of the present.

To the Arctic Regions and Back in Six Weeks, being a Summer Tour to Lapland and Norway, with Notes on Sport and Natural History. By Capt. A. W. M. Clark Kennedy. Map and numerous Illustrations. (London: Sampson Low and Co., 1878.)

THE title of Capt. Kennedy's pleasant volume is rather misleading; before looking into it we thought he would take us as far as Spitzbergen at least, and felt somewhat “sold” when we found his journey ended at Tromsø, in the north of Norway, which, though within the Arctic Circle, is not usually spoken of as in the Arctic Regions. Still Capt. Kennedy's book is thoroughly readable, and though it will add little to our knowledge of Norway or of the Lapps, will prove valuable to any one contemplating a visit to that now much-frequented tourist ground.

LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.]

[The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.]

Eastward Progress of Terrestrial Magnetism

As the progress of weather eastwards is one of the subjects now engaging attention, while the possible connection between meteorological and magnetical phenomena is another, we are led to ask if there be no traces of an eastward progress in certain of the phenomena of terrestrial magnetism.

I cannot yet affirm that such is the case, but it may interest your readers to know that, as far as a preliminary investigation goes, there are some indications of such a progress when we compare together the Declination-ranges at Kew and at Trevandrum. It will, however, require a more thorough discussion before the fact can be considered as at all established.

Manchester, May 4

B. STEWART

The Phonograph

SINCE writing my former letter on the phonograph (NATURE, vol. xvii. p. 485) I have had the advantage of seeing some of the work that Prof. Fleeming Jenkin is doing with his own instrument, which must, I think, be more sensitive than the one I examined. This work convinces me that the phonograph has already risen beyond the rank of lecture illustrations and philosophical toys, to which I assigned it in my last, and that it promises to lay some permanent foundations for the more accurate investigation of the nature of speech sounds. Prof. Fleeming Jenkin, by a most ingenious arrangement, which I must leave him to describe in his paper to the Royal Society of Edinburgh, obtains vertical sections of the impressions made on the tin-foil by the point of the phonograph, magnified 400 diameters. Some of these original tracings I had the pleasure of seeing yesterday, and they are full of interest. I have termed them “speech curves.” They differ considerably from the phonautographic speech-curves of Léon Scott and Koenig, which only succeeded with the vowels, and from the logographic speech-curves of Mr. Barlow, which only succeeded with the consonants, in so much as they succeed with both. In such a word as *tah*, for example, intoned rather than sung, but not simply spoken, as the vowel would otherwise not last long enough for subsequent study, we have first the “preparation,” in which the curve gradually, but irregularly, rises, then the “attack,” where there is generally a bold serrated precipice, with numerous rather sudden valleys; next the “glide” where there is a perfect tumult of curvatures arising from the passage of voice through a continually changing resonance chamber, producing a rapidly and continuously changing but indistinct series of vowel sounds, which gradually settle down into the “vowel” proper. In the vowel, if well intoned, the curve remains constant for a considerable number of periods, beautifully reproducing itself, but, as the intoner becomes exhausted, “vanishing” away gradually to silence, the distinctive peculiarities of the curve disappearing one by one, till a dead level is again reached.

Then Prof. Fleeming Jenkin subjects this vowel curve to “analysis,” reducing it to the separate “pendular” curves of which it can be composed. This corresponds to determining the “partial” tones (*parzialtöne*, *theiltöne* of Helmholtz, of which all but the lowest are called *oberparzialtöne*, *obertheiltöne*, and by contraction *overtöne*, whence the unfortunate English word *over-tones*, which is constantly confused with *partials*, thus assuming a part for the whole) out of which the whole “compound” tone is formed. The first two partials are much stronger than the rest, the second often stronger than the first (hence the frequent confusion of octave?), the others generally very weak, although exceptionally one of the higher partials may be stronger. As many as five partials, as far as I remember, were traced out in the analysis Prof. Jenkin showed me, which he had just received from Edinburgh. The results differ materially for different speakers. Also there is a peculiarity in the “phase” with which the different partials enter into combination. Helmholtz showed that this difference of phase would materially alter the form of the curve, but would not alter the appreciation of quality by the ear depending upon the actual partials and their degrees of loudness alone.

The phonograph, as I have said, resembles rather a worn “print” than a “proof” of the human voice. This means, of course, that the delicate upper partials, on which all brilliancy depends, are absent. In some respects this is advantageous for the very elaborate inquiry which Prof. Fleeming Jenkin has instituted, for it enables him to catch the bold outlines on which genera depend, without being at first bewildered by the delicate details which give specific differences. Our speech sounds are, of course, individual, and what is recognised as the same speech sound varies in the same speaker within the limits of its genus, almost every time it is used. We shall do much if we establish the genus. The extent of Prof. Jenkin's researches, as he contemplates them, and the care with which

his initial experiments, tracings, and analyses have been conducted, lead us to hope that we have at least got an instrument which will enable us to solve the elementary problems of phonetics that have hitherto almost baffled us, although it is not suited, as yet, to fix those delicacies of utterance which were my own special object of investigation.

April 30

ALEXANDER J. ELLIS

ON repeating the experiments with the phonograph narrated by Mr. A. J. Ellis in NATURE, vol. xvii. p. 485, upon a different instrument, I have found the results of my experience to differ in several respects from his. Doubtless each instrument possesses its own individual characteristics; hence it will be the more needful to exercise caution with respect to generalisation, especially as the existing instruments are few and in the hands of few observers. Mr. Ellis has been careful to state the nature of the instrument with which his results were obtained, and the name of Mr. Stroh is a guarantee for the construction of the mechanism. The instrument with which I have been working is of homelier make, and not provided with a driving-train or governor, but simply turned by hand. The same disc—a three-inch ferrotype plate—serves as receiver and transmitter of the voice. The foil used has been, if anything, a little too thin for the purpose.

On trying the sounds *aabaa*, *aadaa*, &c., I found the consonants clearly distinguishable, except the sibilants. *Aajaa*, which is stated by Mr. Ellis to be faultily delivered by the instrument, was perfectly recognisable, and could be distinguished from *aadaa*. Neither was there any confusion between *jack* and *daek* or *tack*; but *jacques*, with the soft *j*, was sounded out by the instrument as *hääk*. My phonograph makes the clearest possible difference between the words *bout* and *bite* when carefully spoken, the diphthongal sounds coming out beautifully as *bääööt* and *bääät*. On reversing the motion of the handle, *täääb* and *täääb* were unmistakable. The double nature of some of our consonantal letters is very clearly demonstrated by this process of reversal of motion, as Messrs. Fleeming Jenkin and Ewing have already shown. To the sounds they name let me add that of *ch* in the word *cheque*, which we ordinarily pronounce *tshek*. This word gives a very peculiar sound when reversed in the machine.

The greatest difficulty—that of getting an instrument to acknowledge the sibilants—is a difficulty that all who have worked with phonograph, phonautograph, or telephone, admit. The remedy mentioned by Prof. Mayer, that of using a mouthpiece with a very small hole, has the inconvenience of diminishing materially the loudness of the articulation of the machine. I have found it better to fasten a strip of card or watchspring across the opening, edgewise, so that the voice impinges on the edge of the strip. With this device sibilants are improved; the word *scissors* becomes practicable, though "*Scots*" is still intractable. One of Mr. Stroh's instruments, which was shown at the Crystal Palace during Easter week, gave *s* and *z* fairly. In a familiar phrase the *ses* are not much missed: *Steady, boys, steady*, is given with less marked defect of speech than if uttered as *thteady, boyth, thteady*. Another point of interest that has not, I think, been yet mentioned by observers is, that the marks corresponding to the vowel sounds differ when the mouth is at different distances from the vibrating plate, but that yet there is no difference in the vowel subsequently emitted by the machine; a result which confirms the previously known independence of the vowel sound of the phase of its component partials. For some time I thought my phonograph guilty of dropping its *h*'s (though not made within the sound of Bow bells), but when that letter is spoken rapidly in a word it is recorded faithfully. *Happy land* is well heard in the instrument; and *How do you do?* is also aspirated. Curiously enough, this sentence is spoken almost as well backwards as forwards (except the aspirate), especially if spoken to the machine with a strong Scottish accent. It is remarkable how useless an instrument without a clockwork regulator is for reproducing even the simplest airs: they are simply lost in noise. Altogether the study of speech by the phonograph is most interesting, and will furnish some most valuable data to students of language and of acoustics. It is impossible to witness its performance without a tribute of acknowledgment to the extreme ingenuity and skill of its inventor, Mr. Edison.

SILVANUS P. THOMPSON

University College, Bristol, May 1

On the Use of the Virial in Thermodynamfics

THE ingenious experiment and the deductions from it, described by Mr. S. Tolver Preston in NATURE, vol. xvii. p. 31, throw a flood of light on the subject of availability of heat-energy, which altogether alters the basis upon which the hitherto imperfectly expressed conditions of the use of this form of energy will be made to rest. Mr. Tolver Preston has, in fact, discovered that discriminating "sprite," or being whom Prof. Clerk-Maxwell imagined ("Theory of Heat," 1875, p. 328) singling out the fast-moving, and separating them in a space by themselves (without any expenditure of energy), from the slow-moving molecules of a gaseous mass; or what is nearly equivalent to this, he has at least shown how some fast-moving and some slow-moving particles of a mass of gas originally in equilibrium, both as to temperature and pressure, will naturally be so guided amongst each other, that their joint energy will become more available than it was before. But it has, perhaps, not occurred to Mr. Tolver Preston and to some of your readers, that this power or faculty of rendering heat-energy available, which mutual diffusion of heterogeneous gas-masses, either through a porous septum or in their own contiguous layers possesses, is a consequence of the general form of efficacy belonging to force, of which Prof. Clausius pointed out the existence in his important propositions on the "virial,"¹ as he has termed one of the two members, of which this kind of mechanical tendency of force is the sum. The other member of a force's "radiant" (as it may be termed), "with respect to a given point," is the *vis viva*² of the material particle upon which it acts, in a space of which the selected point is the origin. In description of this newly-discovered natural tendency of a force with respect to a given point or focus, it is enough to say that while the statical moment of a force, or the product of the distance of its point of application from a point or fulcrum by the resolved part of the force perpendicular to this distance tends to increase uniformly the moment of momentum (defined similarly with that of force) of the particle upon which it acts, so does the "radiant" of a force, or the product of the distance of its point of application from a given point or "focus," together with the *vis viva* of the particle upon which it acts, tend to increase the "radiant of momentum" of the particle described in the same way as the radiant (or the first term of the radiality) of the force, as just defined. We may speak of the radiant of equal and opposite reactions, or of force-pairs, in the same way that we deal in statics with the moments of couples; with similar general properties of their equilibrium, including the resolution of the total radiant (like the impulse, the horse-power, and the moment) of a system of forces, into an internal and an external part with respect to the centre of mass of a material system upon which it acts; and there are principles of conservation of moment and of radiant of momentum about any point, taken as centre, of all the force-pairs whose moments and radiant balance each other on a material system. Only the system's *vis viva* referred to the centre is in the latter case the rate of change of its radiant of momentum relatively to it. It is in the same way that the conservation of the motion of the centre of mass, and the conservation of energy, are principles of nullity or of inaction of two other forms of force-agency balancing each other on a material system (the impulse of forces, and the product of their impulse by the virtual velocity of their point of application, or their "horse-power") to which we are obliged to have special recourse to resolve the particular varieties of questions of the "transfer of energy" which occur in mechanics. But it is remarkable that the radiality of a force-pair includes the *vis viva* of its mass-couplet as one member of its mechanical efficacy, and a surprising example of an agent (evidently the agent of heat-distribution) here presents itself in which *vis viva* itself is one of the active elements of the mechanical variation or compulsion! Its total tendency in any body acted on internally only by directly reacting force-pairs is the total *vis viva*, and the sum of the virials of those force-pairs, diminished, if the body is subjected externally to a uniform pressure normal to its surface, by three times the well-known product of this latter pressure by the volume of the body (written $-3pv$).

¹ Poggendorff's *Annalen*, vol. cxli. (1870), p. 124. But Clausius, it should be remarked, gives the name "virial" to half of the quantity which I have described below as the "radiant" of a force. An exposition of Clausius' new mechanical expression, the virial, with an explanation by its means of the process of condensation of vapours into the liquid state, was given by Prof. Clerk Maxwell in his lecture to the Chemical Society on the molecular theory of the constitution of gaseous and other bodies, in 1875. (See NATURE, vol. xi. p. 357.)

² Using this word for twice the quantity usually described as a particle's "kinetic energy."